5th International Conference on Computational and Mathematical Biomedical Engineering – CMBE2017
10–12 April 2017, United States
P. Nithiarasu and A.M. Robertson (Eds.)

POROVISCOHYPERELASTIC COMPUTATIONAL MODELS OF SOFT BIOLOGICAL TISSUE

Jonathan Vande Geest*, Paolo Zunino†
*Department of Bioengineering, University of Pittsburgh,
302 Benedum Hall, 3700 O'Hara Street, Pittsburgh, PA 15260, jpv20@pitt.edu
†Department of Mathematics, Politecnico di Milano,
Piazza Leonardo da Vinci 32, 20133 Milano, Italy, paolo.zunino@polimi.it

MINI-SYMPOSIUM PROPOSAL

Keywords: *soft tissue biomechanics, constitutive models, computational approach*

1 MINI-SYMPOSIUM PROPOSAL

There is increasing evidence that the deformations of soft biological tissues such as cardiac muscle, the white and grey matter in the brain, and various types of tumors cannot be studied independently of the interstitial fluid motion intimately coupled to these structures. Theoretical investigation and computer simulations represent valuable tools to better understand the interplay of mechanical deformations coupled with interstitial fluid motion. The insight gained with these methods is also helpful to guide the experimental approach, for example by designing more efficient experimental tests for the verification of scientific hypotheses on the complex behavior of soft tissue.

Computational models have been adopted to investigate many fundamental problems of soft tissue mechanics. In cardiac mechanics, the complex interaction of electric signals, heart muscle contraction and its perfusion has been successfully explored using a poroelastic model for heart tissue [1, 2]. Similar models turned out to be effective for fluid-porous-structure interaction simulations of large arteries [3-6].

Another problem that poses fundamental challenges is the understanding of brain mechanics [7]. The importance of this organ and the relevance of its pathologies have motivated the development of new theoretical models [8] and advanced numerical methods [9].

In some cases, such as brain development and tumors, the complexity of the problem is increased by the fact that the material is subject to growth. The theoretical investigation of solid and fluid mechanics coupled to growth is an open challenge that has been addressed in few works [10-14].

This mini-symposium aims to explore these trends in soft tissue mechanics, by gathering researchers active on non-standard constitutive frameworks (poroelasticity, poroviscoelasticity, etc.) applied to model the behavior of soft biological tissues. The scope of the mini-symposium focuses on (but is not limited to) applications to brain tissue, cardiovascular tissues, and cancer. Contributions form the theoretical, computational, and experimental standpoints will be welcome in this mini-symposium.

REFERENCES

[1] Chabiniok, R., V.Y. Wang, M. Hadjicharalambous, L. Asner, J. Lee, M. Sermesant, E. Kuhl, A.A. Young, P. Moireau, M.P. Nash, D. Chapelle, and D.A. Nordsletten, Multiphysics and multiscale

modelling, data–model fusion and integration of organ physiology in the clinic: Ventricular cardiac mechanics. Interface Focus, 2016. **6**(2).
[2] Chapelle, D., J.F. Gerbeau, J. Sainte-Marie, and I.E. Vignon-Clementel, A poroelastic model valid in large strains with applications to perfusion in cardiac modeling. Computational Mechanics, 2010. **46**(1): p. 91-101.
[3] Bukac, M., I. Yotov, R. Zakerzadeh, and P. Zunino, Effects of poroelasticity on fluid-structure interaction in arteries: A computational sensitivity study, in Modeling, Simulation and Applications2015. p. 197-220.
[4] Keyes, J.T., B.R. Simon, and J.P. Vande Geest, A finite element study on variations in mass transport in stented porcine coronary arteries based on location in the coronary arterial tree. Journal of Biomechanical Engineering, 2013. **135**(6).
[5] Vande Geest, J.P., B.R. Simon, and A. Mortazavi, Toward a model for local drug delivery in abdominal aortic aneurysms, in Annals of the New York Academy of Sciences2006. p. 396-399.
[6] Bukač, M., I. Yotov, R. Zakerzadeh, and P. Zunino, Partitioning strategies for the interaction of a fluid with a poroelastic material based on a Nitsche's coupling approach. Computer Methods in Applied Mechanics and Engineering, 2015. **292**: p. 138-170.
[7] Goriely, A., M.G.D. Geers, G.A. Holzapfel, J. Jayamohan, A. Jérusalem, S. Sivaloganathan, W. Squier, J.A.W. van Dommelen, S. Waters, and E. Kuhl, Mechanics of the brain: perspectives, challenges, and opportunities. Biomechanics and Modeling in Mechanobiology, 2015. **14**(5): p. 931-965.
[8] Tully, B. and Y. Ventikos, Cerebral water transport using multiple-network poroelastic theory: Application to normal pressure hydrocephalus. Journal of Fluid Mechanics, 2011. **667**: p. 188-215.
[9] Roy, S., L. Heltai, C. Drapaca, and F. Costanzo. An immersed finite element method approach for brain biomechanics. in Conference Proceedings of the Society for Experimental Mechanics Series. 2013.
[10] Armstrong, M.H., A. Buganza Tepole, E. Kuhl, B.R. Simon, and J.P. Vande Geest, A finite element model for mixed porohyperelasticity with transport, swelling, and growth. PLoS ONE, 2016. **11**(4).
[11] Harper, J.L., B.R. Simon, and J.P. Vande Geest, A one-dimensional mixed porohyperelastic transport swelling finite element model with growth. Journal of the Mechanical Behavior of Biomedical Materials, 2014. **29**: p. 663-675.
[12] Sarntinoranont, M., F. Rooney, and M. Ferrari. Mechanical model of a growing solid tumor: Implications for vascular collapse and drug transport. in Annual International Conference of the IEEE Engineering in Medicine and Biology - Proceedings. 1999.
[13] Sarntinoranont, M., F. Rooney, and M. Ferrari, Poroelastic model of a solid tumor. American Society of Mechanical Engineers, Bioengineering Division BED, 1999. **42**: p. 305-306.
[14] Sarntinoranont, M., F. Rooney, and M. Ferrari, Interstitial stress and fluid pressure within a growing tumor. Annals of Biomedical Engineering, 2003. **31**(3): p. 327-335.